Engineering and Technology Industry Council
Campus Investment Proposal
Biennium from July 1, 2011 to June 30, 2013

Campus: Oregon Health & Science University

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Date of Submission: January 28, 2010 (revised 2/12/10)

Summary of Proposal:

The incidence of aging-related (Alzheimer's) and developmental (autism) neurological disorders is exploding, threatening a society that is ill-prepared due to lacking adequately trained healthcare professionals, accurate diagnostics, and efficient chronic care. Neurotechnology – applying engineering to neurological disorders – can critically help addressing this threat. The charter of the proposed **Oregon Center of Excellence in NeuroTechnology Engineering and Research (OCENTER)** is to support Neurotechnology research and create synergistic commercial and educational opportunities. It leverages strengths in neuroscience, speech technology (Center for Spoken Language Understanding, CSLU), and the largest ongoing trial of unobtrusive in-home assessment (the Oregon Center for Aging and Technology, ORCATECH).

Vision and Goals Statement

The OCENTER will enable Oregon to firm up its leadership position in the development of disruptive technology that will transform healthcare from reactive to proactive and from clinic-centered to home-based, creating unprecedented opportunities for research, commercialization and education. The OCENTER, capitalizing on a foundation of existing strengths, will position Neurotechnology to become a major driver of engineering innovation in the State, by creating a collaborative network of Oregon institutions (OHSU, PSU, OSU, UO) involved in engineering areas such as sensor networks, algorithms for statistical signal processing and pattern recognition, and design and development of scalable platforms and back-office systems.

Investment Description

The budget will cover the hiring of two new faculty and 4 postdoctoral fellows and technical staff at OHSU; salary, technical, and educational support for collaborators at Portland State University, the University of Oregon, and Oregon State University (see Appendix A for Statements of Interest); and equipment (advanced EEG monitoring systems.) These investments are needed to add critical mass, enable an aggressive program of integrated behavioral/EEG research, and solidify cross-institutional collaborations.

Private Support

The number of families with a child, parent, or grandparent who is battling a neurological disorder or suffers from age-related cognitive decline is rapidly increasing. This growth has dramatically enhanced awareness of the acute problems associated with these conditions, providing unparalleled opportunities for philanthropic fundraising. CSLU has received philanthropic contributions for its Neurotechnology research on autism. Also, industrial organizations have already funded related efforts, exemplified by Intel's support for ORCATECH. Based on these precedents, we expect that the OCENTER will be able to raise similar levels of funding from industry and philanthropic sources.

Results and Benefits

Short-term

During this initial period, investments will be made to transition existing (but currently scattered) strengths in Neurotechnology and existing (but still fairly minimal) collaborations into a growing, coherent multi-institutional operation. Toward this end, basic investments in new hires, education, and equipment will be complemented by specific investments in multi-institutional collaboration (e.g., joint pilot studies, invited speaker seminar series rotating among institutions; facilitation of multi-site funding proposal submission) and visibility enhancement (ranging from organizing state-wide publicity events to international conferences). Specific metrics are the following.

(1) Establishment of a multi-institution steering committee, chartered with coordinating Neurotechnology related activities across the state.
(2) Two Neurotechnology-focused faculty hired, with backgrounds in electrical engineering or computer science.
(3) Enrollment of at least 10 students in new Neurotechnology PhD programs.
(4) At least $500K of additional new federal funding of Neurotechnology focused research grants involving multiple Oregon institutions; this will include at least one grant taking advantage of newly purchased EEG equipment.
(5) Federal funding of at least one Neurotechnology focused training grant.
(6) Growth of Neurotechnology related commercial activity (creation of new enterprises and/or growth of existing enterprises).
(7) Organization of state-wide and/or international events relating to Neurotechnology. We note that OHSU has been selected as the 2011 site for the 49th Annual Meeting of the Association for Computational Linguistics [http://www.acl2011.org/], and as the 2012 site for InterSpeech [http://www.interspeech2012.org/]. Both of these are large, Neurotechnology-related, international conferences.

Medium-term

Opportunity trends. The OCENTER, in collaboration with Oregon universities and industry, will be capitalizing on the following powerful opportunity trends:

(1) During these five years (2011-2015), the urgency of addressing neurological disorders and aging-related problems, and of their associated monetary and human costs, will have further escalated because their incidence will further increase and it is unlikely that the US is prepared to attack these issues on the enormous scale needed in this time frame; thus, the perceived need for solutions to these issues will be at a boiling point.

(2) At the national level, it will become increasingly recognized that technological solutions are both necessary and feasible.

(3) This will stimulate already growing interests at the NIH (NIBIB, NLM) and the Department of Defense (ranging from cognitive performance enhancement [http://www.darpa.mil/dso/thrusts/trainhu/nia/index.htm] to closed-head Traumatic Brain Injury) in technologically driven neuroscience research, and a growing interest at the NSF in interdisciplinary collaboration (e.g., the current Cyber-Enabled Discovery and Innovation program), to create substantially enhanced federal funding streams for Neurotechnology R&D.

(4) Importantly, OHSU already has been successful in attracting federal funding from these sources for a broad range of topics (Alzheimer's, autism, Parkinson's, brain-computer interfaces; with foci on diagnosis, intervention, as well as cognitive enhancement), which has given it a substantial head start on other organizations in the country in the area of *Neurobehavioral Engineering* – the application of engineering and computation to behavioral manifestations of neurological disorders.

Deliverables. Based on these opportunity trends, and after successful execution of the 2011-2013 and 2013-2015 biennia objectives, the following deliverables are reasonable: The OCENTER will have Center-grant level funding (either via the NSF STC mechanism or via NIH "P" or "U" mechanisms); a strong Applied Neurotechnology MSc program initiated during the 2013-2015; the graduation of a substantial number of PhD Neurotechnology students; employment of Neurotechnology PhD's and MSc's at Oregon institutions and companies; profitability of one or more of the Neurotechnology companies targeted during preceding biennia; and job creation not only at Neurotechnology companies but also in the much broader market of technical and non-technical support services for extra-clinical (e.g., in-home, in-school) Neurotechnology: a new type of professional with skills at the intersection of engineering, healthcare and social science.

Revenues. We expect the OCENTER to have annual revenues from grants, tuition income, sponsored research, and licensing income of $8M by 2015 (from less than $4M in FY2010, and essentially $0 in 1999), further increasing to $16M by 2020. We thus expect to easily meet the 2X criterion.

Education. Given that Neurotechnology is an emerging area that in 1999 Neurotechnology was mostly only a concept, no meaningful 1999-2020 comparison is possible in terms of the increase of work-ready graduates. We expect, however, that by 2020 we will graduate annually 10 PhD students and 20 MSc students. In addition, we expect new programs to be created to educate the workforce needed to provide technical and non-technical support services for extra-clinical Neurotechnology.

We note that within the general areas of engineering and computer science, biomedically focused research has substantially higher participation by women than other research in these areas; OHSU's BME, CSE, and EE programs have at least 40% female students.

Structure. By 2020, the OCENTER will be a sustainable, nationally and internationally competitive, research and educational organization, sharing certain key organizational features with ONAMI: It will be an inter-institutional collaborative, led by an Executive Director together with a leadership team selected from earlier steering committees, administrative support staff, and infrastructure as needed for cross-institutional sharing of computational resources.

Note on AY99-09 actuals and AY13-20 projections. The Table shows, for the actuals, data on the combination of the three divisions (Biomedical Engineering, Biomedical Computer Science, and Environmental and Biomolecular Systems; and, for the projections, only data on the Neurotechnology component in the Biomedical Engineering and Biomedical Computer Science divisions.

Future Plans & Resources

Key steps taken starting in 2013 include the following.

(1) Successful application for NSF STC and/or NIH "P" or "U" grants.
(2) Creation of a Neurotechnology MSc program.
(3) Initial steps, in collaboration with OHSU School of Nursing and OIT, toward educational programs focused on technical and non-technical support services for extra-clinical Neurotechnology.
(4) Successful ramp-up of new faculty hired during the 2011-2013 biennium
(5) Aggressive pursuit of regular (non-center) research grants and training grants (NSF IGERT [already submitted], NIH T mechanism).
(6) Aggressive pursuit of STTR/SBIR grants (OHSU spinout BioSpeech Inc, a Neurotechnology company, has received >$1M over the past 4 years)
(7) Aggressive publicity at the state, national, and international levels, via website development, organization of local conferences, and organization of international conferences, building on OHSU's organization in two major conferences in 2011 and 2012.
(8) Discussions with local technology companies on R&D investment in Neurotechnology.
(9) Discussions with major out-of-state medical device companies (e.g., Philips Healthcare) on R&D investment in Neurotechnology in Oregon.

Proposed Investment and Private Support Forecast ($M)

		2011-2013 Biennium
1	**Source of funds**	
2	**Base budget for ETIC related programs - all sources except ETIC allocation & private support**	$ 26,500,000
3	**Proposed allocation from ETIC budget ($M) (3) (9)**	$ 3,500,000
4	**Expected private support ($M) (4)**	$ 5,000,000
5	**Total ($M)**	$ 35,000,000
6	**Personnel supported (FTE) (5)**	
7	**Existing faculty (1) (9)**	10.00
8	**New faculty (2)**	2.00
9	**Existing staff (1) (9)**	14.00
10	**New staff (2)**	3.75
11	**Total**	29.75
12	**New positions created (6)**	
13	**Faculty (2)**	2.00
14	**Staff (2)**	5.00
15	**Total**	7.00
16	**Uses of ETIC funds in line 3**	
17	**New facilities**	$ 50,000
18	**Improvements to facilities (7)**	$ 50,000
19	**Laboratory equipment (7)**	$ 300,000
20	**Other equipment (7) (9)**	$ 310,000
21	**Other one-time expenses (9)**	$ 220,000
22	**Existing faculty salaries & benefits (1) (9)**	$ 826,250
23	**New faculty salaries & benefits (2)**	$ 800,000
24	**Existing staff salaries & benefits (1) (9)**	$ 210,000
25	**New staff salaries & benefits (2)**	$ 450,000
26	**Services & supplies (9)**	$ 253,750
27	**Other**	$ 30,000
28	**Total (8) (9)**	$ 3,500,000

Instructions. (replace with your own notes in the document you submit.)

(1) Hired through June 2011 that will be supported by ETIC funds during 2011-13

(2) To be hired with ETIC funds during 2011-2013 biennium

(3) Include any Certificates of Participation to be issued during 2009-2011

(4) Consistent with ETIC Private Support policy dated 1-23-02

(5) FTE expressed as percent of full time over 2 years of biennium. For instance, a new full-time faculty member hired on 7/1/2012 would be counted as 0.5 because he/she joined half way through the biennium

(6) FTE on an ongoing basis. For instance if a new half-time position is created but not expected to be filled until the last month of the biennium, it would still be counted as 0.5.

(7) Include improvements and equipment to be purchased with ETIC funds and any Certificates of Participation to be issued during the biennium.

(8) total on line 3 and line 28 should match

(9) In aggregate these lines include $600,000 to support collaborations with other universities.

Metrics Forecast (for programs/departments receiving ETIC funding):

	Actuals (1) (13) Includes all three divisions - Biomedical Engineering, Biomedical Computer Science and Environmental and Biomolecular Systems		Projected (2) (14) Includes ONLY Biomedical Computer Science and that part of Biomedical Engineering that is part of the Center of Excellence which has only 12 faculty in FY13 and will hire only two additional making a total of 14 in the following years		
	AY 99	**AY09**	**AY13**	**AY15**	**AY20**
Undergraduate student credit hours	N/A	N/A	N/A	N/A	N/A
Graduate student credit hours	10,018	4,812	900	1,000	1,320
Graduation rate, 6-year (3)	87%	73%	75%	77%	80%
Bachelor's degrees granted	N/A	N/A	N/A	N/A	N/A
Master's degrees granted	113	36	10	15	20
PhD degrees granted	16	8	8	9	10
Women graduating (4)	29%	23%	25%	30%	35%
Minorities graduating (5)	21%	18%	25%	25%	25%
Externally-funded research expenditures (6)	15,883,154	12,203,531	8,000,000	10,000,000	16,000,000
Invention disclosures (7)	N/A	23	17	19	22
License/options (8)	N/A	N/A	N/A	N/A	N/A
License income received (9)	N/A	N/A	N/A	N/A	N/A
Spin-off Companies (10)	0	0	1	1	2
National ranking of <Biomedical Computer Science & Biomedical Engineering> (11)	N/A	33	28	27	25
National ranking of <college>	N/A	N/A	N/A	N/A	N/A

Notes/instructions. (Delete these notes and replace with your own in the document you submit.)

(1) Actuals for 12-month period ending in June of the year shown.

(2) Forecast for the 12-month period ending in June of the year shown.

(3) Percentage of undergraduate students who started ETIC-Supported program as freshmen six years earlier who have completed bachelor's degree in an ETIC-supported degree.

(4) From engineering, computer science, and other programs directly benefiting from ETIC funding, stated as percent of all those graduating.

(5) Racial and ethnic minorities who are US citizens or permanent residents, stated percent of US citizens or permanent residents graduating.

(6) Total external dollars spent by ETIC-related departments towards research during academic year.

(7) See Association of University Technology Managers (AUTM) survey definitions.

(8) Number of license or option agreements executed during the year. See AUTM survey definitions.

(9) License issue fees, payments under options, annual minimums, running royalties, termination payments, the amount of equity received when cashed in, and software end-user licnese fees equal to $1000 or more, but not research funding, patent expense reimbursement, valuation of equity not cashed-in, or end-user license fees less than $1000. See

(10) New companies that were dependent on the licensing of your program's technology for their initiation. See AUTM survey definitions.

(11) Forecasts for multiple programs and departments are encouraged. Each ranking should be footnoted with the ranking body or ranking methodology.

(12) Add additional metrics as appropriate.

(13) These numbers are inclusive of the three divisions within the Department of Science and Engineering - Biomedical Engineering, Biomedical Computer Science and Environmental and Biomolecular Systems

(14) These numbers include the two divisions - Biomedical Engineering and Biomedical Computer Science only.

Appendix A

Statement of Interests

Patrick Chiang
Assistant Professor
Oregon State University

School of Electrical Engineering & Computer Science
Oregon State University, 1148 Kelley Engineering Center, Corvallis, Oregon 97331-5501
Phone 541-737-3617 | Fax 541-737-1300 | http://eecs.oregonstate.edu/

Dear ETIC council, Jan. 25, 2010

It is my pleasure to write this letter of support and collaboration for Professor Misha Pavel of OHSU for our joint work together on using future electronics and computing for ubiquitous, non-invasive monitoring of mobility and cognitive function.

My research group focuses on 'sustainable silicon': next-generation electronics for future energy-constrained applications, such as data centers, embedded processors for cellphones, and implantable bioelectronics. Our recent work over the past 3 years has exhibited some best-to-date numbers for energy-efficiency, such as off-chip communications, on-chip interconnect, and wireless transceiver communications. This recent work has been recently gaining much publicity, most recently with a 5-year grant from the Department of Energy Early CAREER award. While our recent success with energy sustainability has gained much traction, our next breakthrough step will be the translation of our energy-efficient techniques to the medical arena to improve healthy aging.

Our group currently has several on-going projects with leading Oregon clinical organizations, where we are working on translational interdisciplinary research that bridge the gap between medical requirements and electrical engineering. For example, we are working with Prof. Hooker (OSU) and Prof. Tucker (UO, Electrical Geodesics) in building non-invasive, ultra-low power and highly-integrated, wireless EEG sensors. These sensors will enable the next generation of 'wireless band-aids', where continuous vital sign monitoring will allow early detection of heart and neurological diseases. Furthermore, we are currently collaborating with Prof. Hayes and Pavel (OHSU) on low-cost, 3D indoor localization electronics, which will enable monitoring and classification of movement patterns of elderly. Such low-cost, low-energy, and small form factor electronics currently do not exist on the market, such that our research innovations will someday enable widespread adoption of such medical technologies to the home. These innovations will also enable future job creation, by connecting Oregon's high-tech engineering workforce with critical medical fields.

We look forward to continued translational research between electrical engineering and clinical end applications, such as our recent healthy aging collaboration with Prof. Pavel's group at OHSU. I firmly believe that the result of engineering innovations applied to medical diseases will be one of the fundamental advances for this century, and I look forward to these collectively addressing these problems.

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January 26, 2010

Dr. Misha Pavel
Division Head, Biomedical Engineering
Oregon Health & Science University
3303 SW Bond Ave, CH13B
Portland, OR 97239

Dear Dr. Pavel,

As director of the Communications and Signal Processing Group at Oregon State University, I am very pleased to join you in your effort to establish a neurotechnology center focused on measurement, monitoring, and inference of behaviors in order to detect and assess neurological diseases and aging-related changes.

I have 20 years of research and development experience on wireless communication systems and technologies. One of my research areas is the pulsed ultrawideband systems and technology, the most promising candidate technology for real-time, high-precision indoor localization. For the effort in building a neurotechnology center, I believe that I can contribute significantly by developing a patient activity/mobility tracking network. Neuroscientists will be able to rely on such network to study patient activity/mobility patterns for modeling of cognitive functions.

I look forward to working with you and making this high-impact center a success.

Sincerely,

Huaping Liu
Associate Professor

James McNames
Associate Professor
Portland State University

The Biomedical Signal Processing Laboratory at Portland State University has been collaborating closely with the Parkinson's Center of Oregon to develop new technologies for people with movement disorders, and Parkinson's disease in particular. This collaboration has also produced a small business called APDM, that is located in the Portland State Business Accelerator.

Parkinson's disease (PD) is the second most common neurodegenerative disease and the most common serious movement disorder. It afflicts approximately 1 million in the US alone costing the economy over $25 billion annually. Levodopa is the most potent antiparkinson drug and is the primary therapy for most patients. However, continual use of levodopa over time causes fluctuations in bradykinesia (slowness of movement), tremor, and dyskinesia (uncoordinated writhing movements) and has variable effects on gait and posture. Accurate assessment of Parkinsonian motor impairments is crucial for optimizing therapy in clinical practice and for determining efficacy of new therapies in clinical trials. This would be a critical component of a Center of Neurotechnology because it provides the means of determining the effectiveness of novel therapies for Parkinson's disease and other neurological disorders.

One of the primary objectives of this multi-institutional collaboration is to develop clinically useful wearable device to continuously monitor movement disorders in the home and community. APDM has developed the world's most advanced movement monitor that is unobtrusive and has sufficient storage and battery life and memory to support the this application. However, funding is needed to develop and validate the algorithms for continuous monitoring of the motor signs of Parkinson's disease. Funding is requested to support a 2 year feasibility study in the homes of 10 subjects that would provide sufficient preliminary data to demonstrate feasibility and support applications to the NIH and national foundations. This would also strengthen the position of a business founded and located in Oregon.

Don Tucker
Professor and Associate Director
University of Oregon

Recent advances in dense array electroencephalographic (dEEG) technology at the University of Oregon Neuroinformatics Center have provided new insights into the neural mechanisms of higher cognitive functions such as self-monitoring and self-regulation. For example, mapping dEEG activity to the cortical surface with high performance computational models of head tissue conductivity has improved the precision of relating brain waves recorded over the frontal lobes to specific corticolimbic networks, including the anterior cingulate cortex and the insular cortex. The activity in these networks may be critical in self-monitoring, such as when a person detects an error in their actions or thoughts and must change their approach or exert more effort to find the correct choice (Luu, et al., 2009; Tucker and Luu, 2006). With the mild cognitive decline of normal aging, such skills of executive self-monitoring remain intact, such that the person becomes highly aware of difficulties in word-finding that may be minimally impaired compared to normal younger persons. With increasing cognitive decline, however, the frontal signatures of self-monitoring have been observed to decrease, suggesting that memory is both impaired and not recognized to be impaired.

LuuLuu, P., Shane, M., Pratt, N. L., & Tucker, D. (2009). Corticolimbic mechanisms in the control of trial and error learning. *Brain Research, 1249*, 100-113.

Tucker, D. M., & Luu, P. (2006). Adaptive Binding. In H. Zimmer, A. Mecklinger & U. Lindenberger (Eds.), *Binding in Human Memory: A Neurocognitive Approach* (pp. 85-108). New York: Oxford University Press.